

Environmentally Sensitive Maintenance for Dirt and Gravel Roads

Chapter 7: Environmentally Sensitive Maintenance Practices: Additional Maintenance Techniques

7.1 Introduction

In the two previous chapters we introduced numerous maintenance practices as tools for the toolbox. In this chapter, we provide additional tools relating to three major topics:

Dust Control: We will define road [dust](#) and learn about its effects on roads and the environment. Armed with this information, we will then discuss [dust](#) control materials and methods.

Road Stabilization: We will define [road stabilization](#) and introduce the materials and techniques most commonly used. Many [dust](#) control materials can also be used as additives in [road stabilization](#).

Geosynthetics: We will then introduce the world of [geosynthetics](#) and their many various functions and uses in environmentally sensitive road maintenance.

7.2 Dust Control

Unpaved roads are considered the largest source of particulate air pollution in the country. According to the Environmental Protection Agency, unpaved roads produce almost five times as much particulate matter as construction activities and wind [erosion](#), which are the next two largest sources, combined.

Many local governments do some sort of [dust](#) control. This maintenance task is usually performed as a result of public complaints, and the resultant work consists of doing some sort of [dust](#) control in front of residences. This action typifies the common thoughts of [dust](#) as a nuisance. [Dust](#), however, is much more than a nuisance. We need to understand exactly what [dust](#) is and how it originates.



7-01 Unpaved roads are the largest source of dust pollution in the country.

7.2.1 What is Dust and Where Does It Come From? First, look at a commonly accepted statement about [dust](#):

“One car making one pass on one mile of dirt or gravel road one time each day for one year creates one ton of [dust](#).”

What is this [dust](#)? Where does this [dust](#) come from? This [dust](#) is part of the road, it's the fines being ground down by traffic and blowing off in the wind. Recalling earlier discussions about road materials, we wanted a well-graded aggregate with fines to lock everything together and keep it in place. If we lose the fines, we lose the road. The above statement translates to losing 50 tons of fine road material a year for each mile of road with an average of 50 vehicles per day.



7-02 Just what is dust? Where does it come from?

When these fines are lost as [dust](#), it deteriorates the gravel surface. Larger aggregate pieces become exposed and are then scattered by vehicles or washed away. The unstable road surface becomes rough, developing potholes and washboarding. These distresses hold water that infiltrates and damages the base. In addition, the eroded material damages ditches and drainage systems. Repairs and maintenance can be frequent and costly.

[Dust](#) indicates the road is deteriorating, and the [dust](#), as it settles out and becomes additional [sediment](#) in the streams or blankets the vegetation, causes deterioration to the environment. Thus, [dust](#) causes excess road maintenance and environmental pollution.

7.2.2 The Necessity of Dust Control. Successful treatment can significantly reduce [dust](#) conditions and help preserve road surfaces. Various studies show that control measures can reduce [dust](#) by 30% to 80% and cut aggregate loss by 25% to 75%. Such treatments, however, will not last forever, and repeated applications may be necessary.

We must view [dust](#) control as a necessary routine maintenance item for all unpaved roads – not only to prolong road life, but also to protect the environment. [Dust](#) control means that the roads will stay intact; the fines will remain interlocked with the larger aggregates and keep everything in place. Similar to the cut in aggregate loss, studies report that one can expect a 25% to 75% cost reduction in blading, reggrading, and re-graveling by implementing a [dust](#) control program.

How often we do [dust](#) control and to what extent will depend on many variables. What are the road surface materials? What is the road condition? What is the drainage

condition? What are the environmental conditions – severe storms, rain, droughts, etc.? What is the volume and speed of traffic? What are the objectives or goals for [dust](#) control?

Without traffic, [dust](#) is not a problem. According to commonly accepted “guidelines,” roads with an average daily traffic ([ADT](#)) between 15 and 500 vehicles per day are good candidates for [dust](#) control. With fewer than 15 vehicles per day, there is probably not a substantial [dust](#) problem. Conditions on these roads, however, must be evaluated on an individual basis to determine the potential for [dust](#)-related problems. Generally speaking, roads carrying more than 500 vehicles per day will require multiple treatments. In these cases, options range from a more substantial surface treatment to an actual asphalt pavement. Again, each road must be evaluated individually based on specific road and roadside conditions.

7.2.3 Benefits of a Dust Control Program. Let’s look at the benefits of a [dust](#) control program. The first two major benefits are what we have already discussed above – prolonged road life with less maintenance and less particulate matter polluting our streams.

But there are many other benefits to a [dust](#) control program, such as reduced respiratory and associated health problems, not only from the [dust](#) itself, but also possibly from other organisms attached to the [dust](#) particles through electrostatic forces.

[Dust](#) on plants can hamper their growth and development. When the farmer calls and wants something done about the [dust](#) because it is affecting his crops, that is a valid complaint. [Dust](#) shades necessary light from plants, hindering [photosynthesis](#) (plants producing their own food), resulting in stunted plant growth.

In general, a good [dust](#) control program reduces cleaning costs associated with homes, clothes, and vehicles. [Dust](#) control can mean a better quality of life and higher property values for those living and working adjacent to your roads.



7-03 Dust can affect crops.

[Dust](#) poses road safety hazards as well because it reduces visibility for motorists.



7-04 Dust creates visibility problems for the motorists.

[Dust](#) control can mean reduced vehicle accidents and improved road safety. If the driver cannot see properly, it is unsafe to drive.

A good [dust](#) control program can also reduce vehicle maintenance costs. [Dust](#) plays total havoc on moving parts. Maintaining a vehicle that drives an average of 40 mph exclusively on gravel roads costs 40% more than maintaining the same vehicle traveling the same speed on paved roads.

If the road fines are lost, the coarse aggregate ravel and loosens and can be kicked up by vehicles, causing windshield breakage and vehicle damage. Good [dust](#) control means less vehicle damage.

And, of course, there is the public and public relations. What municipal official has not received the phone call from the irate resident demanding, “You have to do something about this [dust](#)!”

A good [dust](#) control program means a better road, a better environment, and thus a better community.

7.2.4 Dust Control Options. Road managers have several [dust](#) control options available to them depending on specific road conditions. Traffic creates [dust](#). Limiting traffic volumes, however, is really not feasible. After all, that is what the road is there for. Limiting traffic speed could have an effect. But erecting speed limit signs does not always slow traffic down, and no matter what the speed is, traffic will still create [dust](#). Heavy truck traffic creates more [dust](#), but limiting traffic weight is not an efficient [dust](#) control alternative. Usually weight restrictions are imposed on roads that are incapable of supporting heavy traffic without significant road deterioration especially in the spring “mud season.”



7-05 Traffic weight and speed increase dust.

Although paving the road is the only permanent solution to [dust](#) problems, using effective controls can significantly reduce [dust](#) and cut required maintenance. That leaves

us with [dust suppressants](#) and a few other more substantial methods using [road stabilization](#) and [geosynthetics](#), both of which can help in alleviating the [dust](#) problem.

[Dust suppressants](#) are classified as routine [dust](#) control maintenance items. Of course, different materials will provide different service intervals depending on many variables. We also need to be concerned with the environmental effects of the materials used.

7.2.5 Evaluation of Dust Suppressant Materials. Before we discuss [dust suppressant](#) materials, we need to talk about evaluation of the materials to be used. What should you know? What do you need to consider?

The following list provides the basic considerations:

Environmentally compatible

Effective at controlling [dust](#)

Easily applied with common road maintenance equipment

Workable and responsive to maintenance

Not degrading to ride quality

Relatively harmless to vehicles using the road

Posing little hazard or inconvenience to adjacent residents

Cost competitive

There are several information sources available to help in evaluation of [dust suppressants](#).

Every chemical has to have a Material Safety Data Sheet ([MSDS](#)). Right-to-Know Laws, originating at the federal level and adopted at the state level, require all manufacturers to provide an [MSDS](#) for every chemical and require all employers to have [MSDS](#) sheets for each chemical used in the workplace available to employees.

The [MSDS](#) deals with safety in handling the material, listing the manufacturer's name, address, and phone number; the major components of the chemical; its characteristics such as flammability, volatility, reactivity; safety equipment needed to handle the chemical; and emergency procedures in case of spills or exposure.

The Federal Clean Water Act along with respective state acts set the requirements as to toxicity for fish and other aquatic stream life. The material or chemical must meet all of these requirements. But we also should be concerned with effects on vegetation. We now realize how important roadside vegetation is and the important part it plays in [erosion](#) and [sediment](#) pollution prevention and helping reduce road maintenance. We certainly do not need chemicals that would harm or destroy our roadside vegetation.

It is imperative that road managers evaluate [dust](#) control products in light of all of these factors. Road managers need to seek out all information on the product, check referenced users as to their experiences, concerns, and problems, and possibly do trial

applications to develop an effective, efficient and safe [dust](#) control program that will protect their roads and the environment.

7.2.6 Common Dust Suppressants. The following list of commonly used [dust suppressants](#) along with their attributes and limitations as to effective [dust](#) control and environmental compatibility will be discussed.

- Water
- Sodium Chloride (salt)
- Calcium Chloride
- Magnesium chloride
- Brines (natural, semi-processed)
- Lignin Derivatives
- Asphalt Emulsions & Cutbacks (oils)
- Resins

7.2.6.1 Water. Water is a [dust suppressant](#). Water will do the job but it is short-lived. Road personnel would have to be out there continually each day applying water during the dry summer weather. Water, however, is readily available and safe for the environment.

A notice of “caution” is required here concerning the “safe for the environment” statement. A caution comes with using potable “tap” water from a public water system. A public water system treats water with chlorine for disinfecting to kill all organisms. There is always a chlorine residual in the water. If a tankload of this water would be dumped directly into a stream, you may end up with a detrimental effect on the fish and other aquatic life depending on the volume dumped, the amount of stream flow, the amount of chlorine residual, and other conditions.

Water’s real limitations relate to evaporating readily and thereby its short-term control. This means it becomes very labor intensive and costly due to the need for repeated applications for effective control. Contractors use water trucks on large construction sites continually to cut [dust](#) during work. Not only do they do this to ward off complaints from adjacent residents, but they also know the savings in equipment maintenance. Water as a temporary control during construction or maintenance work does have merit.



7-06 Although environmentally sensitive, water affords only short-term dust control.

7.2.6.2 Sodium Chloride. Sodium chloride is our deicing salt or rock salt used all over the snow-belt states for paved roads in winter. Salt, however, is not an effective [dust](#) control. It begins to absorb water at 76% relative humidity, reduces the rate of water evaporation by a factor of 1.3 times, and it does lower the freezing point of water. However, all of these positive [dust](#) control characteristics are not substantial, especially when compared to other available materials.

There are significant environmental concerns with the use of chlorides. Whether the chlorides come from sodium chloride or from magnesium or calcium chloride, they still pose environmental challenges. When these materials are used, the sodium, calcium or magnesium attach themselves to other materials, but the chlorides become free agents and are able to leach out of the road and into nearby streams or ground water sources.

Chlorides can cause serious problems. They can be detrimental to animals and plants, and they are corrosive. With these limitations and the fact that sodium chloride is not effective as a [dust](#) control, we do not recommend using sodium chloride for this purpose.

7.2.6.3 Calcium and Magnesium Chlorides. Calcium and magnesium chlorides, on the other hand, can be effective [dust suppressants](#). Calcium chloride begins to absorb moisture at 29% relative humidity, which is very dry and when we need [dust](#) control the most. It also reduces water evaporation by a factor of 3.4 times and lowers the freezing temperature of water to -60° F.

Magnesium chloride is very similar and begins to absorb water at a dry 32% relative humidity, reduces water evaporation by 3.1 times, and lowers the freezing point of water to -27° F.

Even with these attributes, calcium and magnesium chlorides are still chlorides, which again can be detrimental to plants and animals and corrosive to metals. Site conditions, particularly where roads are immediate adjacent to streams, must be evaluated carefully if chlorides are being considered for use.

7.2.6.4 Brines. Brines are usually a by-product of gas production wells and consist of a combination of chlorides. Brines, as a by-product, can be less costly than many other materials. Natural or semi-processed brines should be tested and approved for use as a [dust](#) control agent. The manufacturer should be responsible for testing and assuring a non-contaminated product.

Brines, being mostly chlorides, give us the same positive attributes and the same concerns as the other chlorides. Brines can be detrimental to animals and plants, but may be worse in that they could be contaminated with other materials – oils, heavy metals, etc. For this reason, brines need to be tested and approved before use.

7.2.6.5 Lignin Derivatives. Lignin derivatives are a by-product of the paper manufacturing industry. They are highly acidic, usually foul-smelling when spread, and

very sticky, clinging to vehicles. Complaints are common because of these problems, so be sure to give advance notice to residents and businesses before treatment. There is dried processed lignin sulfonate available commercially, which does not have these problems. In addition, certain manufacturing processes may make them more or less effective in controlling [dust](#). For example, ammonium lignin sulfonate refers to the process and is one of the more effective agents.



7-07 Lignin derivatives are a by-product of the paper manufacturing industry.

With lignin derivatives, the road should have a silt/clay content of 4% to 8% for them to take the proper effect in controlling [dust](#). Lignins are slippery when wet and brittle when dry, which is not really conducive to good [dust](#) control. Rain tends to re-emulsify the material, increasing the potential for run-off. And, although lignins could be called a natural substance, if they leach into the stream, they will deplete the oxygen and destroy stream life. Lignins, because of their acidity, are corrosive. Repeated applications will be needed as lignins decompose over time.

7.2.6.6 Asphalt Emulsions and Cutbacks. An asphalt emulsion is asphalt and water with an emulsifying agent (soap) added to allow them to mix. When used, the water evaporates, leaving asphalt. An asphalt cutback is asphalt thinned with a solvent such as naphtha or kerosene. When used, the solvent evaporates, leaving asphalt. These materials act as adhesives and binders that physically glue soil particles together.

They form a hard crust, and repeated applications can develop into a “paved” road. Depending on the number of applications per year, the road conditions and maintenance operations between applications, and the number of years used, the road can start to look and act like a paved asphalt road.



7-08 Asphalt emulsions and cutbacks are still being used for dust control, but...

Using emulsions and cutbacks gives us the asphalt to combine with the gravel road aggregate, forming a paving-like condition, which begins to build an asphalt pavement. Considering that a hot asphalt mix used to pave roads is just asphalt and aggregate mixed and heated in an asphalt plant, one can realize that under continual use of “asphalt oils,” a dirt and gravel road can become that “pancake” paved road. Periodic regrading of the road tends to be more expensive and more

difficult when it has been treated with these products.

These “oils” provide some [dust](#) control. Medium cure cutbacks such as MC30 and MC70 are commonly used. A significant problem related to health and air pollution is the volatile organic compounds (VOCs) released by the asphalt cutbacks. Because of this problem, the use of cutbacks has been limited in many states and will probably continually decrease in the future.

Although they can be applied to a broad range of soil types and are good at waterproofing an aggregate surface, [tracking](#) can be a problem, particularly if the road surface has a lot of fines. [Tracking](#) can be a real nuisance for vehicle owners and nearby residents. Another concern during application is the potential for run-off from excessive application or related to a quick rainstorm.



7-09 With the use of asphalt “oils,” tracking and/or run-off can become problems.

7.2.6.7 Resins and Other Materials. Numerous other [dust](#) control materials are available, including various resins and enzymes, some of which are by-products of a manufacturing process. Vegetable oils including soybean soapstocks and sugar beet extract are also being used. New products are continually being researched and marketed. Once again, all products need to be evaluated in terms of effectiveness and safety in light of site-specific road conditions.

7.2.7 Use and Application of Dust Suppressants. The two main objectives in [dust](#) control, however, remain (1) to develop and implement a program and (2) to use a [dust suppressant](#) that will not only be effective, but also environmentally safe.

7.2.7.1 Environmentally Sensitive Materials. When evaluating [dust suppressant](#) materials, road managers must pay particular attention to each material's environmental impact. Road managers must seek out all information on the product, checking referenced users as to their experiences, concerns, and problems, and then do trial applications to develop an effective, efficient and safe [dust](#) control program that will protect their roads and the environment.

The Pennsylvania State Conservation Commission has addressed the issue of [dust suppressants](#) by making it clear to manufacturers and vendors that they are responsible for determining the acceptability of their materials. [Appendix 7A](#) discusses the Commission's testing protocols and lists the products that have been approved for use in the Pennsylvania Dirt and Gravel Road Program

7.2.7.2 Application Process. No matter what we are using to control [dust](#), the product must match the existing road materials. We should not be doing [dust](#) control with any threat or prediction of rainfall. And remember this important statement:

[Dust](#) control will not make a bad road good, but will keep a good road good.

This leads right into the three major tasks in application of a [dust suppressant](#).

1. Determine the product to be used and application rate. The product may depend on the road and type of wearing surface. Application rate depends on the product; the condition of the road; type, volume and speed of traffic; degree of [dust](#) control required; climatic conditions; frequency of maintenance; and cost.
2. Perform all required maintenance and repairs to the road. Bring the road to a good condition with a good crown and [cross slope](#). Repair unstable areas, remove unsuitable material and replace with select material, make necessary drainage improvements, clean ditches, grade the road, and restore proper crown.
3. Apply the [dust suppressant](#). An application in spring followed by another application in late summer or early fall may give good [dust](#) control for the year. Again, this is dependent on all the variable conditions. Remember, application should be made when there is no threat or prediction of rain for at least 36 hours. Most [dust](#) control agents can be applied when the road surface is damp (not wet), except for the asphalt cutbacks, which require a dry surface.

The following are general application guidelines. Use the recommended application rates from the manufacturer for the first spring application. You may want to reduce this rate by half for roads that have been previously treated. With most products, (asphalt cutbacks are an exception) we can pre-wet the surface with water at rates ranging from 0.03 to 0.3 gallons per square yard to reduce surface tension, to develop capillary

action that allows maximum penetration of the suppressant, and to ensure uniform application. If a [dust](#) coat has already developed on the road, regrade and moisten.

Avoid [runoff](#) or puddling when applying liquids. Use several light sprays if the surface is tight. Follow dry applications with enough water to ensure the pellets or flakes are completely dissolved. Allow the treated road to cure. Curing may take longer for roads with finer grained materials.

A second treatment may be required in late summer or early fall. Treat the road a second time before the first treatment becomes totally ineffective. You may need only half the application rate as used in the spring application.

7.3 Road Stabilization

7.3.1 What is Road Stabilization? We can define [road stabilization](#) as the uniformly crushing, pulverizing and blending of the road materials, adding a stabilizing agent, mixing the agent with the blended material, spreading and regrading the road with proper crown, and compacting. Compaction is a requirement in this process. Stabilization can also be performed without a stabilizing agent but is more commonly done with an agent for better strength and stability.



7-10 Road stabilization or full-depth reclamation works well with a stabilizing agent

The newer terminology for [road stabilization](#) is “full-depth reclamation.”

7.3.2 Advantages of Stabilization. There are numerous advantages to [road stabilization](#). First, stabilization unifies and strengthens the roadbed, prolonging road life. Through stabilization, we are actually recycling existing road materials to reconstruct a new road. The stabilizing materials obtain the desired moisture, increase cohesion by producing a cementing action, and act as a waterproofing, providing greater road strength and stability. The road also becomes more resistant to [dust](#). Depending on the agent added (calcium chloride for example), we can aid in reducing frost action or frost heaves.

Stabilization is nothing new but went by the wayside when asphalt paving and cement concrete paving were introduced for road surfaces. Now we are again discovering

the advantages of stabilization not only for improving our dirt and gravel roads, but also for stronger bases for paved roads.

7.3.3 Stabilization Additives: The common stabilization additives include many of the [dust suppressants](#) with some additional materials added to the list:

- Calcium Chloride
- Magnesium Chloride
- Resins
- Lime
- Cement
- Asphalt
- Fly Ash

Many times these materials are used in combination for stabilization.

Caution: Certain materials may require permits or approval from state environmental agencies for use as a road stabilizer. For example, the use of fly ash in Pennsylvania requires the PA Department of Environmental Protection approval – source, quality, quantity, and how it will be used, stemming from the origin of the fly ash and a potential of unwanted contaminants such as heavy metals.

The same concerns exist for these materials as for [dust](#) control materials, particularly since we are talking about some of the same materials. We do need to be concerned with environmental sensitivity and the effectiveness as a road stabilizer. The same information, testing and evaluation should be a priority, with the manufacturer being responsible for verification of their product being environmentally sensitive. See [Appendix 7A](#) for Pennsylvania's testing requirements and approved products.

7.3.4 The Stabilization Process. Selecting a stabilizing agent is the first step in the process. Selection of the proper stabilizing agent requires knowledge of the road soils or aggregates and of the agent being used. The stabilizing agent must be of the correct type and used in the correct quantity for satisfactory results.

The stabilization process consists of:

- scarifying and pulverizing the existing road materials;
- adding new material if you need to beef up the road structure;
- mixing in the stabilizing agent; and
- then regrading and shaping the road with the proper crown followed by good compaction.

The process can be accomplished with just a road grader and roller. A good grader operator can scarify and mix the materials and reprofile the road, which can then be rolled for compaction.



7-11 Stabilization can be accomplished with a road grader – scarifying the road, mixing in a stabilizing agent, regrading and shaping.

Another viable option is a “reclaimer.” A “reclaimer” has a drum with carbide teeth and a down-cutting action for pulverizing and proper sizing of the material. Stabilizing agents come in liquid or solid form, and are either sprayed using a tank truck or spread using various methods and equipment. The same equipment, such as the reclaimer, can then be used for mixing the stabilizer uniformly with the road material.



7-12 The “reclaimer” has a down-cutting drum with carbide teeth.

With newer systems, a tanker truck connected by a hose to the reclaimer, introduces the liquid stabilizer agent directly into the roadbed material as it is being pulverized. The reclaimer has a computer-controlled liquid injection system, which is capable of accurately regulating additive application rates.

A road grader can then be used to regrade and restore a proper crown and a roller for compaction. Compaction is a requirement in this process.

Stabilization or full-depth reclamation can be an effective tool to reconstruct a poorly maintained road. The end result is a uniform road material strengthened by the added stabilizer agent and properly shaped and crowned for good drainage. Reusing existing road materials is very cost effective.

Full-depth reclamation is recommended for roads like the one in Photo 7-13. The road has a varied look due to a variety of materials that have been used over the years. Different



7-13 A mish-mash of road surface materials lends itself to a full-depth reclamation project.



7-14 A sheep's foot roller is used for soil compaction.

aggregates, different materials for patching, different treatments for [dust](#), or sectional surface treatments all on the same road can be a continuous maintenance headache for the road manager. This type of road is an excellent candidate for full-depth reclamation.

As a side note on compaction, different types of compaction equipment are better suited for different types of materials. If you are compacting soils, a sheep's foot compactor, shown in Photo 7-14, is ideal. This machine compacts the soil from the bottom up. As the soil becomes compacted, the roller will "walk" right out.



7-15a A steel grid-type roller fractures large coarse shale material.



7-15b A rubber tired roller with environmentally friendly ballast.

Large coarse shale materials can be compacted using a grid-type roller, Photo 7-15a, that will tend to fracture and break the larger pieces, helping to consolidate and compact the material into a tight mass. Compaction rollers do not have to be fancy. Photo 7-15b shows a trailer-hitch type with natural ballast materials.

7.4 Geosynthetics

The world of [geosynthetics](#) continues to expand with new products and uses in all types of applications. [Geosynthetics](#) takes in the whole realm of materials such as [geotextiles](#), geogrids, geoweb, geocells, and other geocomposites. Many local governments are using plastic drainage pipe, so they are already into [geosynthetics](#). There are, however, many other products that could prove useful in a variety of areas associated with dirt and gravel road maintenance. This section will zero in on [geosynthetics](#) for pipes and [subdrains](#), for soil [erosion](#) protection and embankment reinforcement, and for road separation fabrics.



7-16 The world of geosynthetics and road maintenance.

First, let's examine just what [geosynthetics](#) are. The prefix “geo” means relating to the earth. The word “synthetic” means man-made. So a [geosynthetic](#) is a man-made material used on or under the earth. The concept of earth stabilization using various materials is not new and can be traced back in history to reed mats in ancient Egypt, bamboo baskets for rice paddies in Asia, and “corduroy” log roads in England. In the United States, woven cotton was used for slope stabilization in South Carolina in the 1930s. All of these materials, however, were from natural products and were biodegradable. Modern [geosynthetics](#) began in the 1950s with trials and experiments, but

really came into existence in the 1970s with the introduction of certain polymers. Today the realm of [geosynthetics](#) is greatly expanded, using many polymers such as polypropylene (PP), polyester (PET), polyethylene (PE), polyvinyl chloride (PVC), nylon, polystyrene, and ethylene interpolymer alloy (EIA), all of which are non-biodegradable.

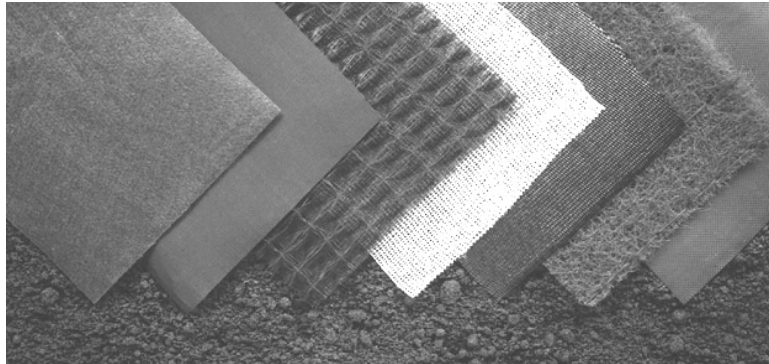
7.4.1 Why Use Geosynthetics? [Geosynthetics](#) are easy to place because virtually all installations can be accomplished with in-house crews. Additionally, [geosynthetic](#) materials cost very little. Low installation costs and low material costs means more bang for the local government buck. Further, [geosynthetics](#) may be used in a wide variety of applications and are durable and long-lasting.

7.4.2 Functions and Applications. [Geosynthetics](#) serve a variety of functions in many useful applications as follows:

Functions	Applications
Drainage / Infiltration	Subsurface Drainage
Stabilization	Subgrade Stabilization
Reinforcement	Soil Reinforcement
Separation	-Embankments
Erosion Control	-Steep Slopes
Sediment Reduction	-Vertical Walls
Waterproofing	Erosion / Sediment Control
Stress Relief	Base Reinforcement
	Bridge Deck Waterproofing

Selection of a particular product depends on the function and application. This becomes extremely important in [geotextile](#) fabrics.

7.4.3 Geotextile Fabrics. There are numerous fabrics on the market; each one designed to perform a specific function. You cannot tell one fabric from another by visual inspection only. Therefore, it becomes imperative that the manufacturer or vendor know how you are going to use the fabric or what function it is supposed to perform.



7-17 Different fabrics are designed to perform various functions and for various applications.

There are two major fabric types: woven and non-woven. The manufacturing process of these two types is similar. Plastic polymer beads are melted down and extruded through dies. For non-woven fabrics, the extruded threads are sprayed in random patterns, and then thermally bonded in layers and needle punched. They commonly have high permeability and conformability with high elongation. For woven

fabrics, the extruded threads are woven on machine looms and have a woven appearance. They have high tensile strength and low elongation.

There are woven slit-film fabrics that are melted plastic beads sprayed in sheet films and then slit into long narrow strips of varying width. These strips are then woven together. They also have high tensile strength and low elongation.



7-18 Fabrics come in rolls of various widths

Fabrics normally come in rolls of various widths. Widths of twelve, fifteen, and eighteen feet are common for use as separation fabrics.

7.4.4 Geosynthetic Applications in Road Maintenance. We have already discussed various [geosynthetics](#) - plastic pipe for drainage applications in directing collected surface flows, perforated plastic pipe for subsurface drainage, [erosion](#) control fabrics for lining ditches or channels, and fabric [silt fence](#) for [sediment](#) control. We will expand on those applications as we discuss further drainage applications, [erosion](#) and [sediment](#) control, separation fabrics, and some other [geosynthetics](#) as used in special applications.

7.4.4.1 Drainage / Infiltration Fabrics. Fabrics can be specifically used in conjunction with [subdrains](#).

Recalling the cross-section sketch of a [subdrain](#) as again shown in Figure 7-1, the

typical construction was a trench with well-graded aggregate and a perforated pipe. Clogging of the system over time has been the major problem with these [subdrains](#), as shown in Photo 7-19. Looking at the photo, one can imagine how much [sediment](#) passed through this pipe prior to reaching this totally clogged condition? And where did all that material go? The [subdrain](#) probably outletted to a stream, and we ended up with stream pollution.

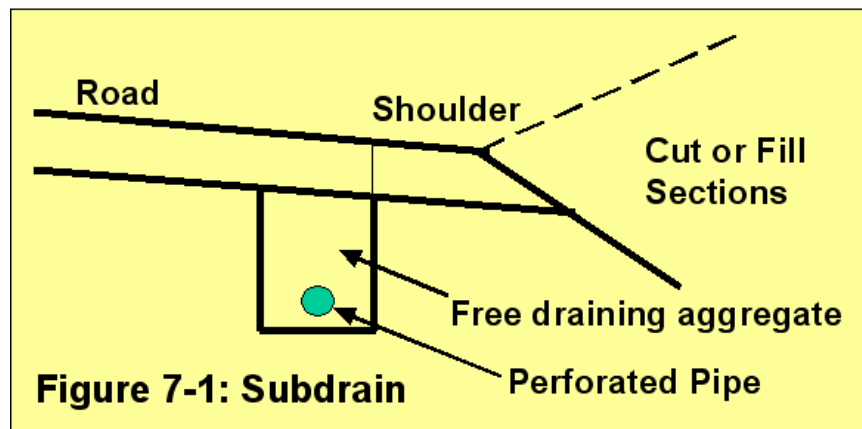
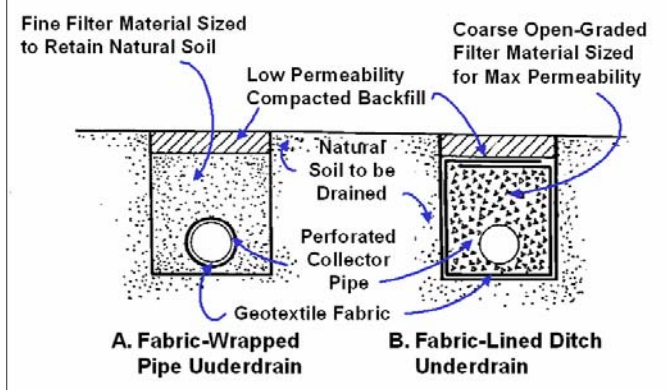


Figure 7-2: Geotextile Fabrics for longer lasting subdrains!



[Geotextiles](#) can play a valuable part in preventing this [sediment](#) and the eventual clogging of the system. You can use a roll of [geotextile](#) drainage/infiltration fabric to line the trench. We could also wrap the perforated pipe or purchased pipe already wrapped in a [geotextile](#) sock, as shown in Figure 7-2. Lining the trench, however, is just as easy and more effective.

The fabric is designed to let the water through and into the trench and pipe and then to the outlet, but it will not let the fine soils through to clog the system.

Caution: *There have been some problems in heavy clay soils – the clay, when wet, becomes very*

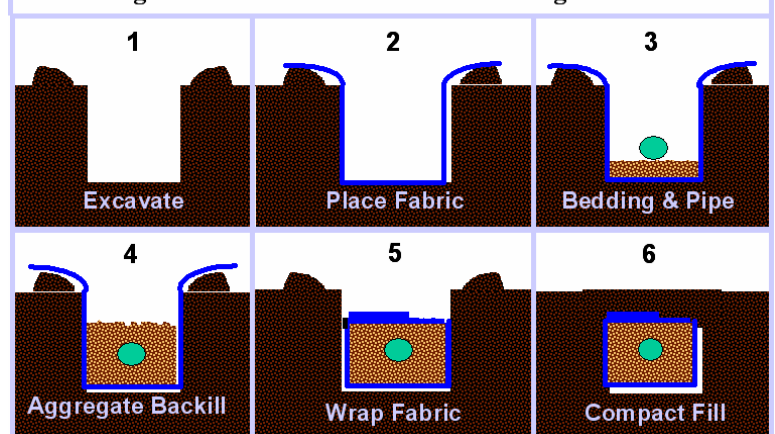
plastic and sticky and has caused some problems when fabric is placed in direct contact with the clay soil.

Lining the trench with fabric is a simple procedure, as shown in Figure 7-3 and the accompanying photos. Dig the trench, roll out the fabric, place bedding, place the perforated pipe, backfill with a one-size aggregate, overlap the fabric on top, and backfill the trench. The result is a better [subdrain](#) system that will last a long time.



7-19 Clogged subdrain!

Figure 7-3: Subdrain construction with geotextiles



7-20 Subdrain construction - dig trench, roll out fabric, add pipe and aggregate, overlap fabric, backfill.

7.4.4.2 Prefabricated

Subdrains. Prefabricated [subdrain](#) systems consist of a hard plastic perforated core covered in a [geotextile](#) fabric. The perforated plastic core becomes the pipe. It is installed vertically, giving you a greater area for draining the road structure. It commonly comes in 12-, 18-, and 24-inch heights. All sorts of connectors are made to accommodate connections and installation. In addition, there are rigid and flexible systems, the flexible system being manufactured in rolls.



7-21 Pre-fab Underdrains: Rigid Type



7-22 Pre-fab Underdrains: Flexible Type



7-23 All subdrains need an outlet.

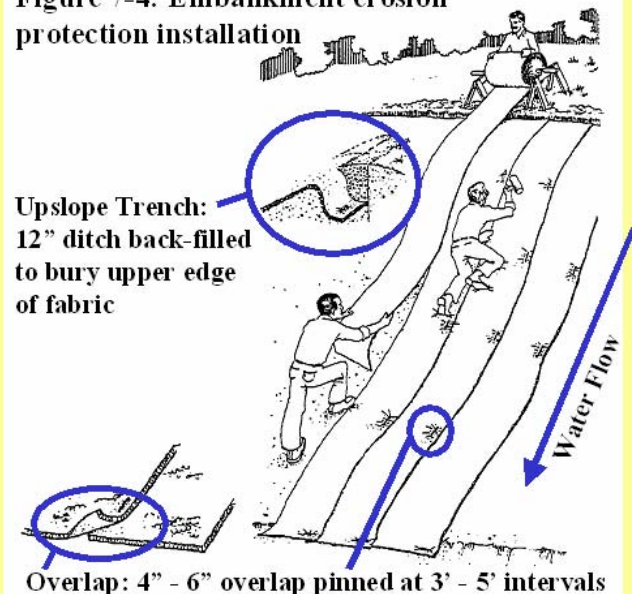
these applications are usually manufactured in rolls and are easily installed with in-house crews, following manufacturer's recommendations.

We already mentioned the use of [geosynthetic](#) in this area in Chapter 5 for ditch and channel linings, where we discussed water flow velocities and the possible need for stabilizing the ditch or channel for faster flows. Many various products are produced for this type of application.

7.4.4.3 Subdrain Outlets. Like any [subdrain](#) system, whether lined with a fabric or a pre-fabricated, all [subdrains](#) must have an outlet. The pre-fab systems, as mentioned, have various connectors to allow the outlet to run in whatever direction is needed.

7.4.4.4 Erosion and Sediment Control. [Geotextiles](#) and other [geosynthetics](#) are used for channel linings and [erosion](#) protection on embankments. [Geosynthetics](#) for

Figure 7-4: Embankment erosion protection installation





7-24 Installation of an erosion control fabric.

This factor applies to embankment protection, too. Again, there are many products on the market for embankment slope protection against [erosion](#).

Normal installation is depicted in Figure 7-4 and consists of rolling out the material, overlapping at seams, pinning, and anchoring the top of the material in a small trench. Again, follow the manufacturer's recommendations for each specific product. Photo 7-24 shows an extensive [erosion](#) control fabric installation, which will be covered with a large-size aggregate.



7-25 Geotextile silt fence barrier.

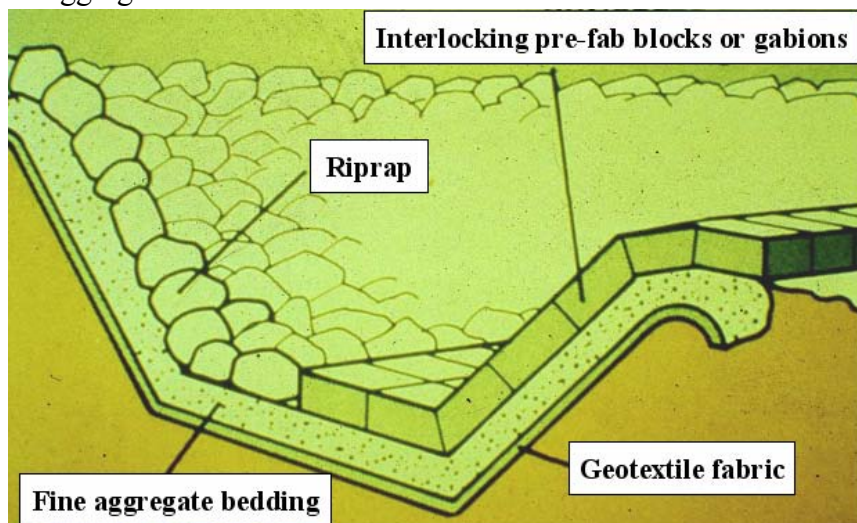


Figure 7-5: Geosynthetic linings serve as reinforcement and separation as well as erosion control

Remember, any type of [geosynthetic](#) is non-biodegradable. If we use these materials for temporary [erosion](#) prevention until vegetation is re-established, we must make sure that they are compatible with that vegetation since they will remain in place.

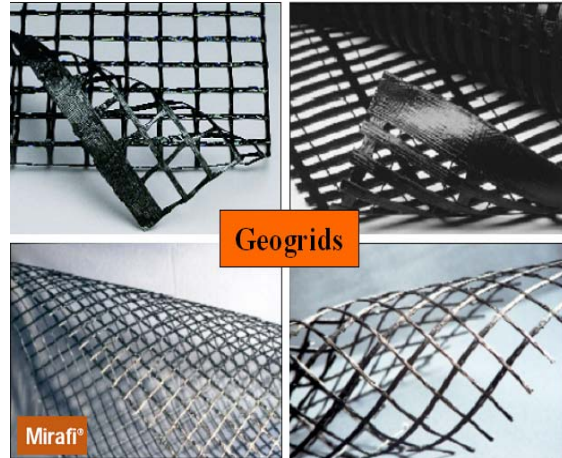
[Silt fence](#) is another [geosynthetic](#) used for temporary [erosion](#) control. [Silt fence](#) is discussed in Section 5.2.3.2 of Chapter 5, describing the proper installation practices and required maintenance.

[Geotextile](#) fabrics are also used underneath other types of channel linings such as [riprap](#) (as in the above Photo 7-24),

[gabions](#), or interlocking pre-fabricated blocks, as shown in Figure 7-5. In this installation, however, they are also serving as reinforcement and separation fabrics that will be discussed below.

7.4.4.5 Embankment Soil

Reinforcement. Both [geotextiles](#) and geogrids are used for embankment soil reinforcement. Geogrids come in many patterns and have proven their ability to perform in this type of application. Reinforcement applications usually entail embankments in which fabric or geogrids are placed horizontally at designed intervals during construction, as shown in Figure 7.6. Alternate layers of fill and rolled-out geogrid are placed as the embankment is constructed.



7-26 Geogrids come in various patterns designed for specific applications.

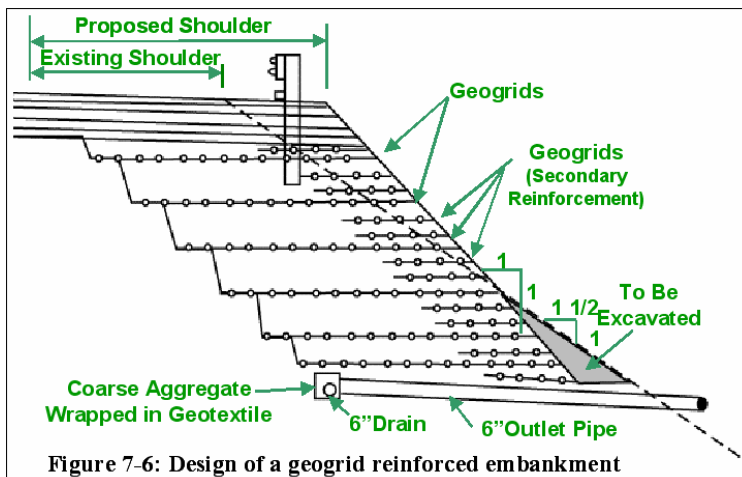


Figure 7-6: Design of a geogrid reinforced embankment

The material can be extended over the face of the embankment for additional protection, a method commonly intrinsic to any design. Photo 7-27 shows an actual road construction site using geogrid for reinforcement - an extensive project, but the applicability is there for any size project.

7.4.4.6 Separation Fabrics. Separation fabrics are among the most commonly used and cost-effective type of [geotextile](#) fabrics on dirt and gravel roads. These fabrics separate the subsoil from the road, provide reinforcement, improve drainage, and reduce [dust](#).

When roads are built, the subsoil or [subgrade](#) is prepared with a crown, then a specified thickness of aggregate is laid down and compacted, (Figure 7-7a).

Over time, however, depending on conditions (water and traffic), the aggregate gets pushed down into the soils, and the soils pump up through the aggregate. We end up



7-27 Construction of a geogrid reinforced embankment.

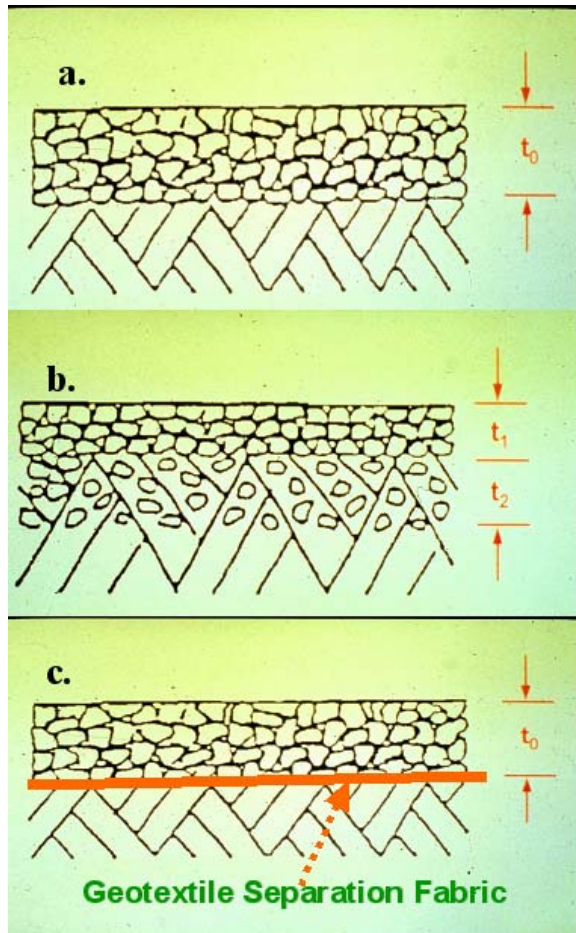


Figure 7-7: Separation Fabrics

with a transition zone not as strong as the aggregate, and the road can no longer support the traffic loads with deterioration as the result (Figure 7-7b).

With the separation fabrics, we prepare the [subgrade](#), roll out the fabric, and build the road on top of the fabric. The aggregate cannot be pushed into the soil and the soil cannot pump up into the aggregate. Everything stays in place, and the road remains as strong as designed for the traffic loads (Figure 7-7c).



7-28 Separation fabrics keep the soil and road aggregate in place.

Water can travel either way, but if it gets into the road, it can drain downward or out laterally due to the crown into side ditches or subdrains. The prevention of soil fines from pumping up through the aggregate to the road surface eliminates the mud in wet weather and the [dust](#) in dry weather associated with these fines.



↑ Rolls of fabric waiting for installation ↑



↑ Rolling out the fabric ↑



↑ Backdumping the aggregate ↑



↑ Spreading the aggregate ↑



↑ Compacting the aggregate ↑

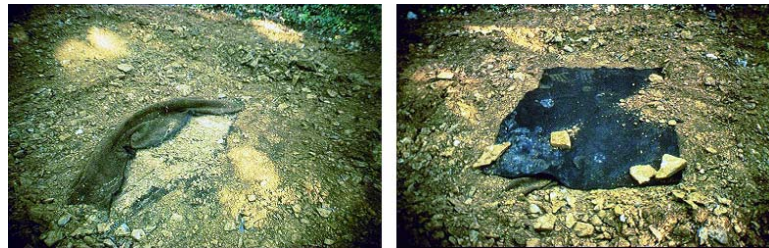


↑ Final grading ↑

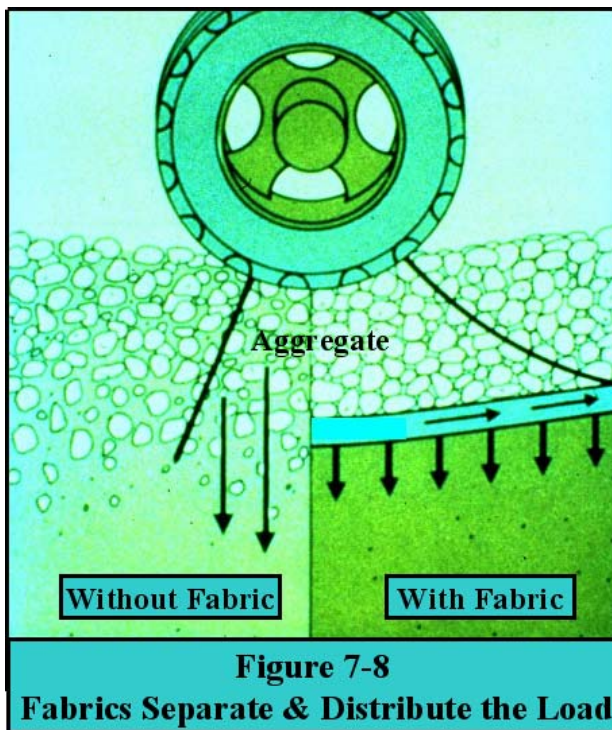
7-29 Installation of a Separation Fabric.

Fabrics come in woven or nonwoven types for this application. The existing road conditions, particularly the aggregate, rock outcrops, water and saturated subsoils, must be evaluated when selecting fabric type. Transverse joints should be overlapped a minimum of 18 inches in the direction of traffic. Fabrics come in standard 12-, 15-, and 18-foot widths (or customized to any width), eliminating the need for longitudinal joints. Aggregate should be backdumped from the truck to a minimum depth of 6 inches, preferably 8 inches. Compacting the aggregate along with grading and re-establishing the crown completes the project. The photos depict fabric installation on a typical dirt and gravel road. This was a demonstration project where both woven and non-woven separation fabrics were used along with different road aggregates. In some areas, filling of the road with shale material to raise the road elevation took place. The different road materials can be seen in the photos.

If the fabric gets damaged during placement, simply patch with another piece of fabric making sure that an 18" overlap on all sides is maintained. Tears can happen, as shown in Photo 7-30, where the blade of the dozer caught the fabric by accident.



7-30 If damaged, use a fabric patch with 18" overlap.



Fabrics also help to distribute traffic loads over a greater area, making them advantageous to use over soft, saturated soil conditions. Figure 7-8 shows this load distribution effect of the fabric. Traffic load distribution was discussed in Chapter 5, Section 5.3.5, Practices Related to [Culverts](#) in regards to [culvert](#) installations.

Many separation fabric applications are in place throughout the states and proving effective in substantial reduction of road deterioration and the required maintenance. The use of fabrics for stabilizing water crossing areas in conjunction with [broad based dips](#) and driveways was mentioned in Chapter 5. In these applications, they perform a reinforcement function and a separation

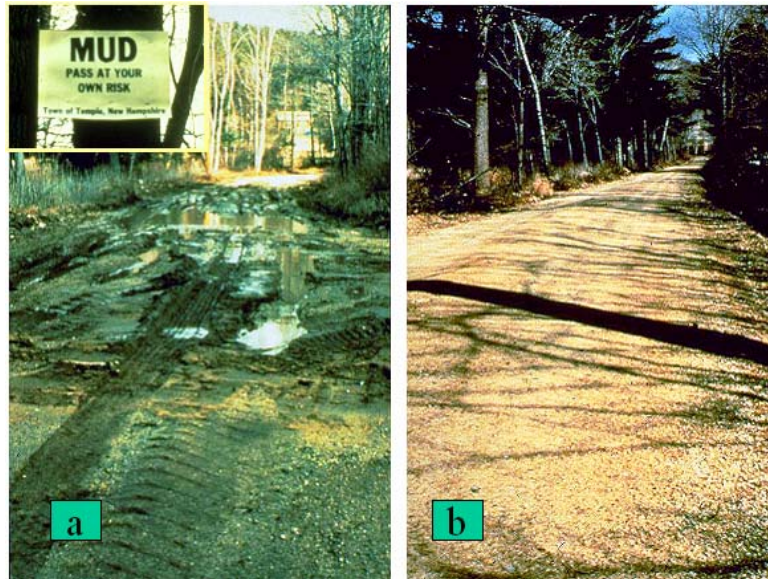
function to strengthen and keep these areas intact.

The use of separation fabrics, in general, provides us with a number of advantages. Stabilization

1. [Subgrade](#) pumping prevention
2. Drainage improvement
3. Excavation reduction
4. Rutting and pothole reduction
5. [Dust](#) reduction
6. Reduced maintenance and costs
7. Longer road life.

The excavation reduction refers to those areas where we find unsuitable saturated soils for [subgrade](#) material. The common practice is to remove the unsuitable material.

This can lead to excavating several feet depending on conditions. With a separation fabric, we can prepare the [subgrade](#) surface and roll out the fabric over these soft soil areas and let the fabric handle the problem. Would you rather have a road looking like “a” or “b” in Photo 7-31? With separation fabrics, we can eliminate the sign as seen in the photo inset.



7-31 Before & after fabric installation – let’s eliminate the sign!

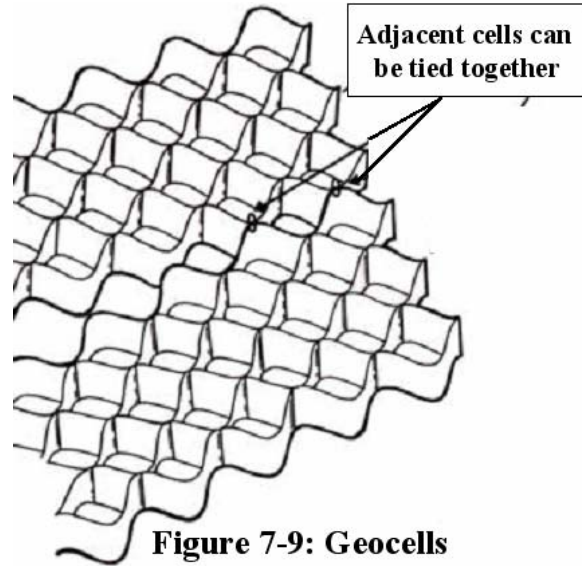
7.4.4.7 French Mattress. The French mattress refers to the old “French drains” used in

many locations to drain storm water. The French mattress is a mattress-shaped structure of coarse aggregate wrapped in a [geotextile](#) fabric. This structure is placed under the road and allows water to pass freely through the roadbed without moving soil particles.

The primary purpose of the mattress is to equalize the subsurface water on both sides the road while providing the needed load support for the road and traffic. Support strength is provided by the large aggregate in the lower portions of the mattress spreading the load.

7.4.4.8 Geocells and Geoweb.

Geocells or geoweb, as they are also called, are an innovative [geosynthetic](#) product used in ground stabilization, road [subgrade](#) stabilization, slope [erosion](#) control, embankment reinforcement and retaining walls, stream crossings, and channel [erosion](#) control. The geocell is a lightweight, flexible mat with a honeycombed structure that is spread and pinned and then filled. A variety of fill materials can be placed within the cellular system, such as soil, sand, aggregate, concrete, etc. The geocell confines the native or select fill materials, adding to the structural strength of the system. Geocells with the appropriate fill material creates various opportunities for economical solutions in the applications listed above.



7-32 Geocells can be filled with a native or select fill material. (Photo: WebTec, Inc. - TerraCell®)

The cells come in various heights with different cell sizes. They can be solid wall or perforated to allow flow between cells. Most manufacturers will also customize sizes for specific requirements. Anchoring systems vary according to the manufacturer.

We will look at a few different applications that could benefit the maintenance of dirt and gravel roads and roadsides.



7-33 Geocells for road base stabilization. (Photos: WebTec, Inc. - TerraCell®)

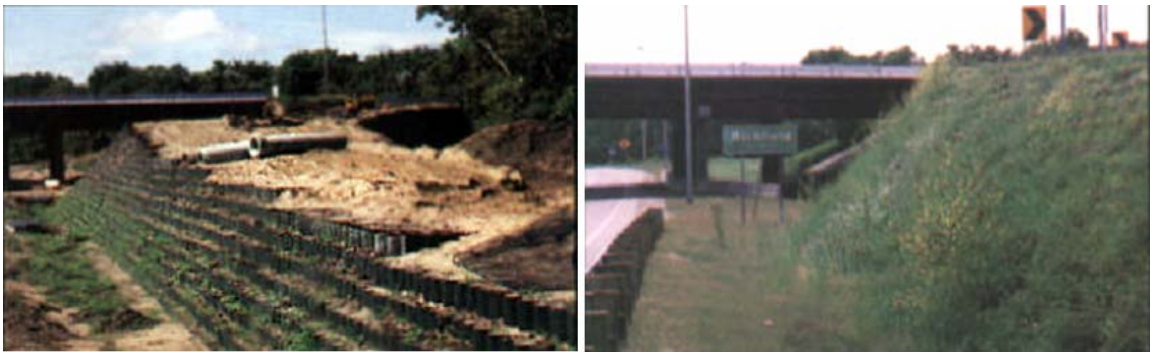
7.4.4.8.1 Road Stabilization. Geocells have been used to stabilize road base aggregates and give additional structural support to the road. The geocell is spread, pinned, and filled with aggregate, as can be seen in the photo. Common practice uses a [geotextile](#) fabric placed on the [subgrade](#) prior to spreading and pinning the geocell. The [geotextile](#) separation fabric

prevents fines from pumping up through the geocell and aggregate and to prevent the aggregate from sinking into the subsoil underneath and to keep a uniform geocell surface across the road. A final surface aggregate would then be spread over the base aggregate and geocell system.

7.4.4.8.2 Retaining Walls. Geocells can be stacked to form almost vertical walls for embankments. As with geogrids, the structural strength of the geocell wall allows for steeper slopes than most soils would sustain without the geocell confinement system. Typical wall installations are shown in Photo 7-34. Each layer of geocell is stepped back from the underlying one.



7-34 Geoweb retaining wall installations (Photos: WebTec, Inc. - TerraCell®)



7-35 Geoweb embankment retaining wall during construction and after vegetation established (Photos: WebTec, Inc. - TerraCell®)

The cells can be filled with soil and vegetation established to actually conceal the wall cellular structure. A vegetated geocell wall is shown in Photo 7-35

7.4.4.8.3 Low Water Road Crossing. A low water crossing can be used in lieu of a cross [culvert](#) being installed. This practice should be used on a very low volume road and will depend on the conditions of the surrounding terrain and the expected flows.



↑ Excavating trench ↑



↑ Placing fabric ↑



↑ Placing geocell ↑



↑ Pinning geocell ↑



↑ Geocell ready for fill ↑



↑ Dumping aggregate fill ↑



↑ Raking fill ↑



↑ Raising road elevation ↑



↑ Compacting ↑



↑ Completed low water crossing ↑

7-36 Installation of a low water crossing.

The series of Photos 7-36 depicts the installation of a typical low water crossing using a geocell. This site was on a road having less than 10 vehicles a day (<10 [ADT](#)). The road was in the [watershed](#) of a potable water reservoir. The storm water accumulated and crossed the road at this point during most storms, causing a great amount of [erosion](#) and road deterioration. The project was designed to raise the elevation of the road but still allow the water to cross naturally at this point through a stabilized low water crossing. A cross pipe installation would create major problems due to elevations of the surrounding terrain. On the downhill side the pipe would have to be extended several hundred feet to outlet at ground level. A low water crossing allowed the water to cross the road in lieu of a cross pipe and sheet flow through the wooded vegetated area without the resulting [erosion](#) and road washouts.

A shallow trench excavation is made to install the crossing. As in the road base reinforcement, a [geotextile](#) separation fabric is placed prior to the geocell. The geocell is then spread and pinned. Large aggregate is dumped into the cell to an elevation slightly higher than the cell in order that the vehicle wheels do not strike the cell.

7.4.4.8.4 Road Stream Ford Crossing. A [geosynthetic](#) reinforced ford crossing enhances the environmental sensitivity of an existing crossing in lieu of a costly bridge construction project. The reinforced crossing provides a stabilized hard aggregate surface

for vehicles that will not wash out and will not create the continual [sediment](#) and disturbance of the stream that the existing unstabilized crossing causes with each vehicle crossing.



7-37 Stream fords cause erosion and sediment, degrading stream habitats. A perforated geoweb offers a stabilizing solution with proper hydraulic and stream ecology protection.

The existing ford crossing shown in Photo 7-37, depicts the [erosion](#) potential with each vehicle crossing, with the resultant [sediment](#) degradation of the stream [ecology](#) (the stream community or [ecosystems](#) was discussed in Chapter 4, Section 4.3, and particularly the effect of [erosion](#) and [sediment](#) on streams in Section 4.3.4). Using a perforated geoweb with one-inch holes allows hydraulic equalization and migration of stream life. The surface of the crossing should match the streambed surface in order not to cause any disturbance in flow by creating a dam effect across the stream.

7.4.4.9 Prefabricated Geosynthetic Pipe Endwalls. Prefabricated [geosynthetic endwalls](#) consist of polyethylene sections that can be easily installed by road maintenance



- Low Density Polyethylene
Easy to install



- Consists of 3 preformed sections
+ a pipe adapter

crews. The [endwalls](#) come in three preformed sections with a pipe adapter for 12", 18", and 24" diameter pipe. One person can position and assemble the sections using a power drill or screwdriver and galvanized screws. The sections are filled with

7-38 Pre-Fab Geosynthetic Endwall Systems.

soil, sand, aggregate, or cement and a cap is placed on top. Additional sections can add height as required. A poured concrete footer is recommended. The [geosynthetic](#) end wall comes in three natural stone colors, and, from the motorists' point of view, look like laid stone [endwalls](#).

The photos (HartmanEW™ System) show an installation sequence for the [endwall](#).



7-39 Pre-Fab Geosynthetic Endwall Installation.

7.5 Summary

This chapter has discussed the importance of implementing a [dust](#) control program. Since [dust](#) is actually the fines in your road that lock everything together should be reason enough to have a [dust](#) control program. A [dust](#) control program prolongs road life, protects the environment, and provides many additional benefits to your community.

We also discussed the importance of evaluation of [dust](#) control products as to their effect on the environment and their effectiveness as a [dust](#) control, followed by a review of common [dust suppressants](#) with their advantages and limitations. We concluded with general application procedures for [dust](#) control products.

In the second section, we delved into [road stabilization](#) (or full depth reclamation) and the benefits derived from this technique. [Road stabilization](#) can add strength to the

road, prolonging its life and reducing maintenance. At the same time, keeping the road intact reduces [erosion](#) and [dust](#), thereby helping the environment.

The third section introduced the world of [geosynthetics](#), describing the functions and applications applicable to dirt and gravel roads. This world is constantly expanding with new products and applications. But products like the separation fabrics have had wide use and success in road maintenance.

Appendix 7B continues, as in Appendices 5 and 6, to review actual Pennsylvania worksites in which a combination of practices has been used, including [geosynthetics](#), to solve the [erosion](#) and [sediment](#) pollution problems stemming from dirt and gravel roads. The first site used pre-fabricated [subdrains](#) to collect subsurface water stemming from spring seeps. The second site was a nature reserve where separation fabrics were used for driveway re-construction and geogrids provided the structural strength for a bus parking lane and a French mattress system provided the required subsurface drainage flows. The third site was a demonstration project where [geotextile](#) fabric was used to reinforce and stabilize a stream crossing having an inadequate crosspipe.

All of these topics and the products and practices discussed are good “tools” for your toolbox and need to be considered as integral parts of an overall environmentally sensitive dirt and gravel road maintenance program.